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Landscape influence on recent rural migration in the U.S.☆

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Abstract

This study of recent rural (nonmetropolitan) migration in the U.S. finds that, consistent with research on landscape preferences, people have been most drawn to areas with a mix of forest and open land, water area, topographical variation, and relatively little cropland. A simultaneous equation model of 1990–2000 change in jobs and net migration indicates that landscape features influenced migration directly, not through effects on employment. An inordinate rise in housing values in the most highly scenic areas in 1990–2000 was associated with an exceptional slowing of migration to those areas in 2000–2005, an indication that housing supply constraints such as land use regulation may now be dampening the ties between landscape preferences and migration in rural areas. The study findings on current habitat selection are particularly interesting given the frequent conjecture that landscape preferences are adaptive, reflecting the most suitable habitats for early man.
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Keywords: Landscape preferences; Natural amenities; Migration; Housing values; Rural population change

1. Introduction

Research on landscape preferences has consistently found people to most prefer park- or wooded savannah-like scenes, with traversable foregrounds, open vistas, clumps of trees and a water source (Ulrich, 1986). Although less evident among people dependent on other landscapes for livelihood, e.g., farmers (Van den Berg et al., 1998) and foresters (Ribe, 1989), these preferences appear largely independent of culture (Stamps, 1999; Yu, 1995).

Despite considerable research on the characteristics of preferred landscapes and the introduction of policies to preserve and enhance scenic landscapes (Dramstad et al., 2006) the salience of these preferences remains open to question. Research has shown that exposure to natural settings – often in contrast to urban or built scenes – reduces stress. (Kaplan and Kaplan, 1989; Parsons et al., 1998; Ulrich, 1984; Van den Berg et al., 2003), but these studies have not differentiated across types of natural scenes. Research on housing prices is providing evidence of the importance of particular landscape features: people pay more for views of water and open space (Benson et al., 1998; Luttik, 1999). Housing studies, however, tend to explore only aspects of landscape within somewhat limited areas.

The present study uses a third metric: rural area migration. Given that migration is a major life decision, correspondence between preferred landscapes and migration would provide strong evidence of a fundamental importance of landscape. Migration is also of interest given the evolutionary biologists' argument that contemporary landscape preferences reflect a genetic predisposition for the wooded savannah-type habitat most suitable to early man (Orians, 1980; Wilson, 1984). If the "savannah hypothesis" is correct, we should find evidence for it in contemporary choice of habitat.

The largely and increasingly urban character of today's settlement patterns would seem at first to deny the relevance of landscape preferences for contemporary habitat selection. However, despite urbanization, the U.S. has long had a flow of people out of metropolitan (urban) areas – counties with urban centers of 50,000 or more residents and nearby counties with extensive commuting to the central counties – to nonmetropolitan (rural) areas. In the 1990s, as in the 1970s, this outflow actually exceeded the movement from rural to urban areas, although some rural areas in the middle of the country had substantial population loss from migration (Johnson, 1999) (Fig. 1).

Drawing on landscape aesthetics research, this paper reports the results of a study of the ways that preferred landscape fea-

☆ The views expressed here are those of the author, and may not be attributed to the Economic Research Service or the U.S. Department of Agriculture.

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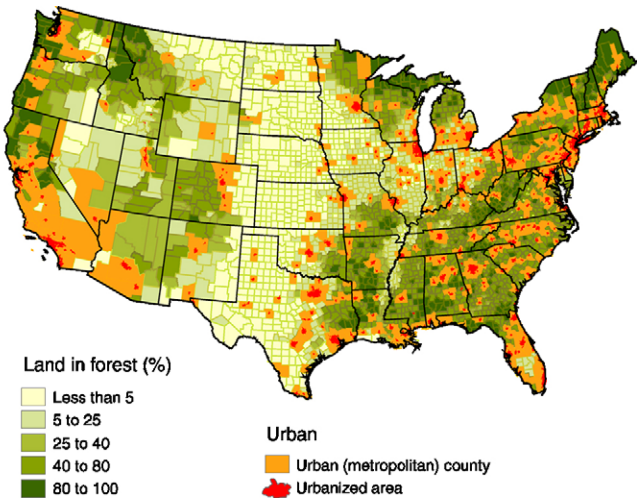

Fig. 1. Rural county land in forest.

tures have shaped rural county migration in the U.S. since 1990. The wide variety of landscapes found in the U.S., the high geographic mobility of its population, at least compared with western Europe (Cheshire, 1995), and the limited influence of rural cultural heritage make the rural U.S. an especially suitable setting to explore the relationships between natural landscape characteristics and migration. The study results suggest that the elements of preferred landscapes have been major factors in recent rural migration.

There is, however, a caveat. Residents in highly scenic areas, seeing further in-migration as a threat to the very landscape qualities that drew them initially, may adopt regulations to constrain further growth. Housing values are inordinately high in the most highly scenic rural counties and they no longer have the highest rates of migration, suggesting that as people seek to preserve their landscapes, migration will increasingly be shaped by efforts to preserve valued landscapes rather than by landscape preferences themselves.

The rest of the paper is divided into 6 sections. Section 2 provides a brief background on migration research in the U.S., particularly as it has applied to rural areas and amenities. The next section covers landscape preferences and measurement and presents ordinary least-squares (OLS) regression analyses of recent migration with landscape and population density as independent variables. While the results of these analyses are consistent with landscape preferences research findings, alternative explanations are possible. Section 4 incorporates alternative explanations of net migration in 1990–2000 in a simultaneous equation format with change in the number of jobs and migration allowed to affect each other. Relationships between landscape characteristics and migration are somewhat attenuated in this model, but the analysis provides strong evidence that landscape influences county migration quite independently of changes in jobs or demographic, industrial, or labor market characteristics. Section 5 deals with the issue of housing supply constraints, to explore the extent to which these constraints have limited migration to preferred landscapes. Study implications are then discussed in the concluding section.

2. Migration research and amenities

It has long been clear to regional scientists and others that amenities play an important role in migration. In a major treatise on regional growth in the U.S. during the 1950s, Perloff (1960) pointed to California, Arizona, and Florida as states where climate and other amenities were major sources of rapid growth. Initial empirical work to isolate the importance of amenities focused on climate, which is relevant for migration to both urban and rural areas (Graves, 1980). In an analysis of county groups, Mueser and Graves (1995) considered percentage lake area in addition to climate in an analysis of net migration that spanned three decades. They found that climate and water had a consistent and substantial bearing on migration, while economic variable relationships varied from one decade to the next. In an analysis of the U.S. Midwest, Williams (1981) used land in forest, but found in a simultaneous equation model of population and employment change in the Midwest that recreation industry growth led to rather than followed population growth in the 1960s. Other studies have focused on particular policies related to outdoor amenities, such as the impact of wilderness areas in the West (Duffy-Deno, 1998) and forest conservation in the forested areas across the upper Midwest and Northeast (Lewis et al., 2002).

Two recent national level studies have used multiple indicators of outdoor amenities to examine rural growth. McGranahan (1999) used four climate measures, a measure of topographic variation, and lake, pond and ocean area as a percent of county area to analyze population change 1970–1996. Deller et al. (2001) constructed land, water, winter sports, climate, and recreation infrastructure measures through a factor analysis to analyze growth in income, jobs, and population in nonmetropolitan counties. Despite multiple indicators, these studies, like their predecessors, used very partial measures of landscape and offered no theory as to why some landscape features might be more attractive than others. In short, previous research results, while not inconsistent with the premise that landscape preferences directly influence migration, provide little direct evidence for that premise.

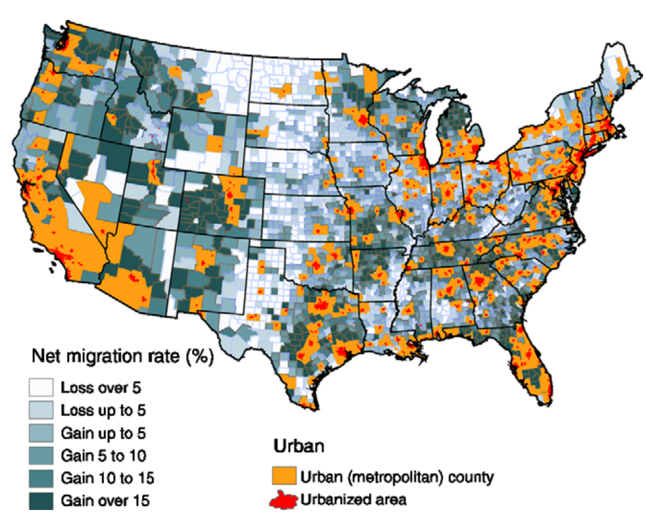

Fig. 2. Rural county net migration, 1990–2000.

3. Landscape and net migration analysis

In most research on landscape preferences, the objects have been particular scenes, usually captured in photograph (Daniel, 2001). This present study, like other U.S. rural migration studies, uses counties as units of analysis. In considering migration to a county area, it is not particular scenes that are being assessed. Any given area landscape is apt to have numerous settings and viewpoints of varying scenic quality (Dramstad et al., 2006). Of interest then is the general capacity of the county landscape to yield scenic beauty. This general focus is consistent with Luttik (1999), who found that regional landscape features were important for housing values, quite independently of the particular setting of a housing unit.

Ulrich's (1986) generalization of the types of scenes most preferred in landscape preferences studies served as a starting point. He, like others, refers to abstract qualities such as, "moderate complexity," "depth," as characteristic of preferred landscapes. These qualities, however, have been largely abstracted from research landscapes containing some mix of trees, shrubs, grass and perhaps other features. Thus, Ulrich (1986) suggests that urban park- or savannah-like settings, with a mixture of trees and open cover, a depth of view, and ease of movement, and a water feature, are visual approximations to the most preferred landscapes—they have the preferred abstract qualities (p. 32). This observation has a great deal of face validity as parks (and golf courses, which tend to have similar characteristics) are constructed landscapes and presumably constructed landscapes reflect preferences. Moreover, these park-like qualities resonate with Orians' (1980) description of the type of landscape most suitable for early man.

The study used five landscape ingredients: forest, cropland, water, topographic variation, and population density. While earlier migration research has used land in forest as a measure, the presumption has been that more forest is better (Williams, 1981; Deller et al., 2001). Landscape preferences literature makes clear, however, that it is a mix of forest and open land that is most preferred. In the multiple regression format used in this study, this was taken into account by using both the percent of land in forest and its square in the analysis. The expectation was that the relationship between net migration and forest would have an inverted "U"-shape, with a positive coefficient for the first term and a negative coefficient for the squared term.

Cropland was expected to dampen migration. Cropland has generally been found associated with lower preference rankings in previous research (Kaplan and Kaplan, 1989), although not for farmers (Van den Berg et al., 1998). Cropland may be more appealing in a "rustic" setting where the field layout and farm buildings have cultural heritage significance and individual fields are relatively small (Strumse, 1994), but these attributes seem less characteristic of U.S. agriculture than European agriculture.

The presence of a water source has invariably tended to increase the preference levels (Ulrich, 1986). Research does not make clear that more water is always better, however. I used the percent of county territory classified as water in the 1990 Census of Population as the basis for our measure. Since county boundaries extend out into large lakes or ocean, the proportion was set to a maximum of 25%. Finally, the natural log of the percent was taken, to normalize the distribution and reduce further possible effects of outliers.

Topography was taken from a topographical map (U.S. Geological Survey, 1937). This map had two dimensions embedded in its 21-point topography scale: a scale of the general topography, which ranged from (1) plains to (5) hills and mountains; and a 4-category scale of relief within each general topography type. Thus, the general type with the most overall variation, "hills and mountains," ranged in relief from (1) hills, to (2) high hills to (3) low mountains to (4) high mountains. One general topography type included a 5-category relief scale, which was collapsed to 4 categories. In coding individual counties, the assigned score was the highest that covered at least 1/4 of the land area. The topography score, formed by multiplying the general topography dimension score by the relief dimension score, ranged from flat plains (1) to mountainous (20). The map does not include the newer states of Alaska and Hawaii and their counties are not included here.

The final consideration is density, which presents a bit of a conundrum. Landscape preferences research has shown that people prefer rural to urban scenes and fewer rather than more built structures (Ulrich, 1986), which suggests thinly settled areas are the most attractive. However, services are sparse in thinly settled areas. Moreover, it is not clear that, as residents, people would not prefer to have at least some neighbors. To take account of these trade-offs, both the natural log of population density and its square were included in the analysis with the expectation of a negative coefficient for the second term, yielding an inverted U-shape relationship as expected for percent of land in forest. Even if expectations are born out in the analysis, however, this is a case where an alternative explanation – housing costs – needs to be explored. Housing typically costs more in denser areas, so migration to less dense areas could simply reflect cost of living concerns.

The net migration data for 1990–2000 are derived from the U.S. Censuses of Population in 1990 and 2000 and vital statistics data on births and deaths in the intervening years (Johnson et al., 2005). Because of the substantial expansion of the rural prison population in the 1990s and the inclusion of the prison population in the migration population, counties with over 20% of their population resident in institutions were excluded from the analysis. U.S. Bureau of the Census net migration estimates are used for 2000–2005.

3.1. Results of regressions of net migration on landscape features

Forest is the key landscape attribute in this study (Fig. 2). Migration associated with water or varied topography may readily be interpreted as reflecting interest in active outdoor recreation – boating or mountain skiing, for instance – rather than aesthetic response to landscape. In the case of forest, active outdoor recreation opportunities are probably greatest where forest is most extensive. However, landscape preferences research

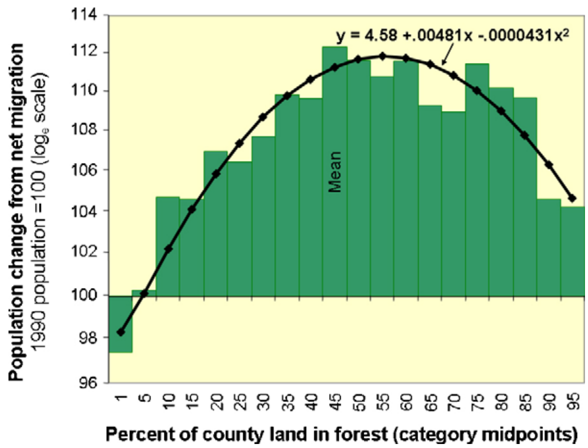

Fig. 3. Rural county land in forest and net migration, 1990–2000.

and theory suggest that people prefer a mix of forest and open land.

The relationship between migration and land in forest clearly conforms to this theory (Fig. 3). Areas with little or no forest tended to have net out-migration between 1990 and 2000. Counties with over 90% forest had only about 4% net in-migration. However, counties with 45 to 60% forest had an average of about 11% in-migration. The regression of migration on land in forest and the square of land in forest tends to capture this relationship, with, as expected, a negative coefficient for the squared term. Both regression coefficients are highly significant statistically ($p < .0001$) and the variance explained (corrected for degrees of freedom) is over 17%, effectively equal to the 18% explained by the categories of the bar graph.

OLS regression analyses including all the landscape measures are presented in Table 1. Equation 1 includes all of the landscape measures for all rural (nonmetropolitan) counties. All of the coefficients are highly significant in this equation and the R^2 is 26%. Landscape is important, but there are clearly other, omitted characteristics that affected rural migration in 1990–2000, an issue we turn to in the next section.

I ran three variations of Equation 1 analysis to further test the landscape hypothesis. First, I explored whether migration to the most rural counties, those relatively remote from major urban areas and lacking urban centers of their own, was more influenced by landscape than migration to more urban counties. As a rule, urbanization means less economic dependence on the local environment and greater dependence on manufacturing and business services. Consistent with expectations, Equation 2 results for the most rural type of counties has a substantially higher R^2 than found for all rural counties.

Second, I explored whether the landscape measures were simply capturing large regional differences across the country. The maps show that the U.S. has broad areas with similar levels of net migration (Fig. 1) and forest (Fig. 2). Other landscape features also have broad regional patterns, with much of the cropland in the Midwest and most of the high mountains in the West, for instance. The landscape measures could thus be reflecting regional differences in a number of factors besides landscape. However, a "fixed effects" model, with states included as dummy variables, shows only a slight decline in some of the coefficients for the landscape measures (Equation 3). The landscape measures are not simple proxies for broad regional differences across states.

Finally, I explored whether the results were particular to 1990–2000. While U.S. Bureau of the Census population estimates suggest little overall net migration to rural areas in 2000–2005, the landscape measures continued to have a substantial bearing on estimated net migration during this period (Equation 4). The coefficients are generally smaller. To some extent this reflects the lower overall migration rates as the standard errors are smaller as well, but in Section 5 we will see that housing availability may have been a constraint on growth in the most highly scenic counties during this period. The major difference in the results between the two periods is the greater concentration of migration in more densely settled rural counties in 2000–2005.

4. Landscape, net migration, and job growth: a simultaneous equation model

The central aim in this section is to explore the alternative hypothesis that the associations between migration and landscape features reflect not the direct bearing of landscape on migration but indirect relationships. In particular, landscape features may be associated with changes in jobs, which then affect migration. Thus, the negative relationship found between cropland and migration may reflect declining jobs in agriculture due to technological change and farm consolidation rather than an avoidance of heavily cropped areas by quality-of-life migrants. Similarly, water and topographic variation may lead to marinas and ski facilities and draw new residents because of job availability rather than scenic attributes. A secondary aim is to consider the extent to which labor market, demographic, and other county characteristics account for relationships between landscape features and net migration.

To test whether landscape has a direct bearing on migration, I developed a simultaneous equation model allowing job growth and net migration to affect each other over 1990–2000. One approach that has been taken in modeling employment and population change simultaneously, the "regional adjustment" model, assumes that local economies converge toward a common ratio of employment to population—equilibrium (Carlino and Mills, 1987; Carruthers and Vias, 2005). Perhaps because of the relatively long time period involved, this model proved too restrictive here, failing Basmann's (1960) test of overidentification restrictions by a large margin. (The test is described below.) Accordingly, I followed Leichenko (2001) and adopted a less restrictive model that allowed job change and net migration to affect each other over the study period.

The initial model was:

$$\Delta P_{\mathrm{M}} = f(\Delta J, Q, r, L, D, A)$$

$$\Delta J = f(\Delta P_{\mathrm{M}}, d, I, L, D, A),$$

Table 1
Coefficients (×100) from OLS regressions of rural county net migration (ln) on landscape and density measures

Measures	Equation 1			Equation 2			Equation 3			Equation 4		
	1990–2000			1990–2000			1990–2000			2000–2005 (10 yr rate)		
	Rural counties			Completely rural counties[a]			Rural counties, fixed effects[b]			Rural counties[c]		
	B	S.E.	$Pr > \|t\|$	*B*	S.E.	$Pr > \|t\|$	*B*	S.E.	$Pr > \|t\|$	*B*	S.E.	$Pr > \|t\|$
Forest (%)	0.353	0.033	<.0001	0.516	0.074	<.0001	0.297	0.037	<.0001	0.123	0.030	<.0001
Square of forest	−0.0041	0.0004	<.0001	−0.0049	0.0007	<.0001	−0.0030	0.0004	<.0001	−0.0018	0.0003	<.0001
Water area (ln %)	1.361	0.252	<.0001	2.058	0.469	<.0001	1.539	0..269	<.0001	1.438	0.222	<.0001
Topography scale	0.500	0.052	<.0001	0.492	0.115	<.0001	0.517	0.070	<.0001	0.464	0.046	<.0001
Cropland (%)	−0.096	0.014	<.0001	−0.066	0.032	0.0340	−0.049	0.017	0.0050	−0.092	0.013	<.0001
Population density (ln)	13.165	1.343	<.0001	14.235	2.484	<.0001	10.605	1.374	<.0001	7.823	0.958	<.0001
Square of density	−1.098	0.116	<.0001	−1.395	0.306	<.0001	−.842	0.121	<.0001	−0.519	0.099	<.0001
Constant	424.99	3.64	<.0001	423.32	6.84	<.0001	430.58	3.76	<.0001	434.09	2.068	<.0001
R^2 (adjusted)	0.255			0.404			0.376			0.303		
N	2209			508			2209			1967		
Maxima												
Forest[d]	48.8			56.6			54.3			47.0		
Density (ln)	4.97			5.10			6.30			7.54		
Persons per square mile	20.0			8.2			27.1			93.7		

[a] Counties with no centers of over 2500 residents and not adjacent to an urban (metropolitan) county.
[b] Includes dummy variables for states (not shown).
[c] Uses 2003 definition of rural, based on 2000 Census of Population.
[d] Rural county means of land in forest and cropland are 37 and 32%, respectively. Maxima assume cropland is half of the land not forested.

where ΔP_M and ΔJ represent change in population due to migration and change in jobs, respectively, Q is a set of quality-of-life measures including landscape and climate, I is a set of employment by industry measures, L represents labor market conditions, D are age and race/ethnicity demographic measures, and A represents additional measures described below.

The initial assumption was that quality-of-life factors would affect the change in number of jobs only through their influence on migration and that industry structure would affect migration only through affecting the change in jobs, with two important exceptions. First, it was expected that people might be directly drawn to counties with high recreation employment (r) because of the availability of facilities and services and because the presence of recreation may indicate outdoor amenities not captured in the landscape measures. Second, it was expected that job growth would correlate with population density (d) due both to the consolidation of services in larger centers (Adamchak et al., 1999) and the need for manufacturers and other larger employers to have access to labor. Brief rationales for the inclusion of other measures follow next.

Quality-of-life: The landscape measures have been described above. Four climate measures were used: average January sun days; average January temperature; average July humidity; and temperate summer, the negative residual of a regression of July temperature on January temperature. As noted earlier, many migration studies have used climate measures. McGranahan (1999) found all four of these measures to be associated with rural population change, 1970–1996.

Industry: The proportions employed in each of six industry categories were used: farm production, mining, manufacturing, producer services (including legal, financial, and business services), recreation (accommodations, restaurants, arts, entertainment, and recreation businesses), and other, with the last serving as the comparison group and omitted from the analysis. Farm employment has historically been declining, although the 1990s were not difficult for farming. Mining has also had a history of decline. Rural manufacturing was under competitive pressure from overseas producers in the 1990s and manufacturers that did not shift production overseas often adopted labor-saving technologies. While overall manufacturing employment was stable until the end of the 1990s, counties with high levels of manufacturing often lost jobs. In contrast to the first three industry categories, business services and recreation gained considerable employment in the 1990s and were expected to have a positive relationship with job change.

Labor market: High employment rates and high household incomes were expected to attract new residents but discourage job expansion. At the same time, high rates of secondary school and university degree completion were expected to encourage job formation but, since we are controlling statistically for employment rates and income, be associated with lower migration.

Demography: The population age 8–17 in 1990 graduated from secondary school or entered the labor market over 1990–2000. Since many rural young adults must leave if they are to attend university or enter the armed forces, the proportion in this age range was expected to be associated with greater out-migration, hence lower net migration. At the same time, a high proportion in this age range represents labor force growth in the coming decade and a positive association with job growth was expected.

A high proportion aged 62 and over once signified a declining area with a loss of youth. While this remains so in areas of the U.S., a large retirement-age population is now more likely to indicate an area attractive to that population. Thus, a positive relationship with net migration was expected. However, since many are out of the labor force, a large and presumably growing retirement-aged population was expected to be associated with less job growth (for any given level of net migration).

The proportions of the population that were Hispanic, Black, or Native American were included as controls. The general expectation was that counties with minority populations might have less growth.

Additional measures: Four additional county characteristics that may affect migration but do not fit easily into the above groupings were also included. First, urban sprawl has been occurring near large and small cities (Johnson, 1999). We capture this both through the proportion of workers commuting out of a county in 1990 and county adjacency to a metropolitan area. Second, much of forest land in the U.S. is public land and migration to forested areas – and many mountainous and lake areas as well – may represent attraction to areas with public lands. I included the proportion of county land in the public domain as an additional measure. Third, some suggest that cultural and other services associated with colleges and universities are attractive to retirees and others. They may also represent a source of trained employees, human capital for economic growth. The proportion of the population age 18–24 enrolled in post-secondary school was included to capture this potential influence. Finally, military bases are important employers in some rural counties. During the 1990s, there was a general decline in the military population, which may have lead to a general loss in population and jobs. This characteristic was measured as the proportion of the population age 20–24 in the military.

The sources, means and standard deviations for the measures are included in Appendix A, Table A1. As in earlier analyses, the following simultaneous equations exclude counties with prison populations comprising over 20% of the total in 2000. Incompatibilities between the employment and migration data sources resulted in the exclusion of Virginia independent cities as well. Finally, 5 outliers with unique circumstances were excluded. Two were casino development counties, for example, where the number of jobs rose by over 600% in 1990–2000, with relatively little gain in migration. The final N was 2194.

4.1. Results from simultaneous equation analysis

An initial run of the model suggested two inadequacies in its formulation. First, Basmann's (1960) test of overidentification restrictions indicated problems of misspecification in both the migration and job change equations. In a simultaneous equation model, measures excluded from one side of the equation are assumed to be related to that dependent measure only through their relationship with the other dependent measure. Thus, water area is assumed to be related to employment change indirectly, because it is related to migration and migration is related to employment change. The Basmann (1960) test indicates the likelihood that this assumption – or set of assumptions, where there are several measures omitted from the side in question – is incorrect, given relationships among the measures in the analysis and the study *N*.

The tests showed that at least one industry measure omitted from the migration equation was related to migration directly, not simply through change in the number of jobs. Similarly, one or more landscape and climate measures were directly as well as indirectly related to job change. Mining was an obvious candidate for the migration equation, as mining often has a detrimental influence on landscape as well as water and air qualities. The addition of mining to the net migration equation reduced but did not eliminate the problem, so farming was also added to the migration equation. While farm employment did not decline appreciably in 1990–2000, there had been a farm "crisis" in the late 1980s that may have had lingering effects on migration in the early 1990s. This did eliminate overidentification in the net migration equation.

The misspecification in the employment equation was eliminated by adding the topography measure to the job change equation. Recreation industry aside, employers may avoid mountainous areas such as the Appalachians and the Rockies because of transportation problems. Moreover, as shown below, housing costs are very high in highly scenic areas, tending to raise wage costs except perhaps for (typically high-end) workers willing to trade income for natural amenities.

The second inadequacy was revealed by a basic Moran's I test (Anselin, 1988) for spatial correlation among the residuals from the migration equation, suggesting that county migration was being influenced by regional factors not encompassed in the model. A map of the residuals showed that migration was being overestimated in northern California and upper New York State and underestimated in the vicinity of Denver, Minneapolis, St. Paul and Atlanta, all rapidly growing metropolitan areas. To build regional factors into the model, the ($\log_e$ of) aggregate change in jobs 1990–2000 in adjacent metropolitan and nonmetropolitan counties was added as a measure in the migration equation. This reduced the Moran's I from .30 to .16, which was considered acceptably low.

The overall results of the 3SLS analysis are presented in Table 2. The R^2 (adjusted for degrees of freedom) are 66% for net migration and 45% for job change, and 61 and 37%, respectively for the reduced form (OLS-equivalent) equations—see Appendix A, Table A2. These compare favourably with other national level analyses of rural counties. The corresponding reduced form R^2 in Deller et al. (2001), for instance, were 29 and 16%, respectively. Although not all coefficients were significant, they were in the expected direction. High incomes and employment rates, for instance, tended to encourage gains from migration but dampen job growth. A large population age 8–17 has a direct effect of lowering net migration (as many young adults migrate out for college, the military, or city lights), but the effect is dampened by the positive effect on job growth.

Of central interest here, however, are the landscape results, which indicate that landscape has a direct influence on migration not attributable to employment change or the other county characteristics in the analysis. The landscape coefficients are all significant, although for the water area measure and density the level of confidence is not as high. The coefficients for the forest indicate a maximum migration level at 53% forest area, in line with earlier results. For density, the maximum is much reduced, to 4 people per square mile—about the density of the Scottish Highlands. Employment opportunities appear to be the main factor drawing people to higher density areas.

To gauge the influence of landscape, we can ask how 1990–2000 migration would have changed in the average rural Iowa county, if the average county were 50% forest and 25% cropland rather than the actual 5% forest and 75% cropland. According to the reduced form migration equation, rural Iowa county average net migration, which was less than 1% in 1990–2000, would have been a substantially higher 7.5%, all other factors remaining equal. If rural Iowa lakes and ponds were not the actual 2% of county area but 7% as in Sawyer County, Wisconsin, net migration would have been an additional percentage point higher. At least to the extent that we have been able to capture the features of preferred landscapes described by Ulrich (1986), landscape preferences appear to provide strong motivation in people's migration decisions. These preferences are not lightly held.

5. Housing supply and migration to scenic areas

Recent research has shown that urban growth in the U.S. is shaped not only by job opportunities and the residential appeal of local areas, but also by the cost and availability of local housing. Urban economist Glaeser (2007) goes so far as to suggest in a recent study of urban "megaregions" that differences in housing supply, resulting largely from local housing and land use regulations, have been the key determinant of U.S. regional growth over the past 20 years.

There are several reasons to expect that housing supply differences affect rural migration patterns as well. First, in highly scenic areas, residents may see further growth as threatening their quality-of-life and adopt land use and other policies to limit further growth. Also, some of these areas, particularly in the West, have extensive public lands, which limits land available for residence. To the extent that these factors limit housing construction, net migration may under represent the attractiveness of highly scenic areas—those with varied topography, a mix of forest and open space, and surface water.

Second, in areas with cropland, in-migration may be limited by any of a plethora of state and local policies enacted specifically to preserve farmland from alternative uses—such as residential development (see Hellerstein et al., 2002). Moreover, in the Midwest, at least, the last 15 years has seen extraordinary rises in farmland prices associated with improvements in farm income and high farm program payments (Novack, 2003). These gains may have spilled over into local housing markets. Housing supply constraints reflected in high housing values could

Table 2
Structural equations from 3SLS analysis of net migration and employment change, 1990–2000[a]

Independent variables	Net migration, 1990–2000			Employment, 1990–2000		
	B	S.E.	*Pr* > |*t*|	*B*	S.E.	*Pr* > |*t*|
Landscape						
Forest (%)	0.1106	0.0262	<.0001			
Square of forest	−0.0012	0.0003	<.0001			
Water area (ln %)	0.3273	0.1365	0.0166			
Topography scale	0.2259	0.0439	<.0001	−0.2357	0.0627	0.0002
Cropland (%)	−0.0386	0.0107	0.0003			
Population density (ln)	2.4736	1.1092	0.0258	1.6059	0.3311	<.0001
Square of density	−0.3618	0.1001	0.0003			
Climate (standardized)						
January sun days	0.5174	0.1809	0.0043			
January temperature	1.1970	0.2386	<.0001			
July humidity (low)	0.5537	0.1968	0.0049			
Temperate summer	0.2944	0.1511	0.0515			
Industry						
Farming	−0.1225	0.0299	<.0001	0.0437	0.0498	0.3799
Mining	−0.2395	0.0901	0.0079	−0.2684	0.0762	0.0004
Manufacturing				−0.1043	0.0355	0.0033
Business services				0.1966	0.1239	0.1128
Recreation	0.1382	0.1290	0.2840	0.3443	0.1007	0.0006
Labor market						
H.S. diploma, age 25–44 (%)	−0.1535	0.0323	<.0001	0.1080	0.0492	0.0282
B.A./B.S. degree, age 25–44	−0.0744	0.0518	0.1509	0.1198	0.0672	0.0748
Employment rate, age 16–64	0.1327	0.0370	0.0003	−0.0297	0.0557	0.5939
Median household income (ln)	3.7273	1.5639	0.0172	−7.0020	2.1380	0.0011
Demography						
Population age 8–17 (%)	−0.9829	0.1282	<.0001	1.2565	0.1469	<.0001
Population age 62 and over (%)	0.2861	0.0604	<.0001	−0.3920	0.0816	<.0001
Native American (%)	−0.0686	0.0257	0.0077	0.1010	0.0351	0.0041
Black (%)	−0.0326	0.0329	0.3218	−0.1247	0.0199	<.0001
Hispanic (%)	−0.1105	0.0200	<.0001	0.0329	0.0245	0.1786
Other						
Commute out of county (%)	0.0805	0.0255	0.0016	1.2565	0.1469	<.0001
County adjacent to metro area (0–1)	0.8422	0.3398	0.0133	−0.3920	0.0816	<.0001
Public land (%)	−0.0245	0.0164	0.1350	0.1010	0.0351	0.0041
College enrollment, age 18–24 (%)	−0.0321	0.0153	0.0365	−0.1247	0.0199	<.0001
Military employment, age 20–24 (%)	−0.1251	0.0484	0.0098	0.0329	0.0245	0.1786
Growth 1990–2000						
Net migration (instrument)				86.688	0.0488	<.0001
Employment (instrument)	48.160	0.1186	<.0001			
Employment in adjacent counties	18.889	3.771	<.0001			
Intercept	146.65	37.85	0.0001	62.21	24.34	0.0107
R^2 (adjusted)	0.66			0.45		
Tests for over identifying restrictions						
		d.f. = 1			d.f. = 9	
		d.f. = 2162			d.f. = 2162	
		$F = 1.7$			$F = 0.72$	
		$Pr > F = 0.1928$			$Pr > F = 0.6886$	

[a] Coefficients and standard errors are multiplied by 100 for exposition.

provide an alternative explanation for the negative association found between cropland and net migration.

Finally, Carruthers and Vias (2005) suggest that population density is associated with lower housing supply. Higher density itself means that the supply of open land is limited, and this unavailability is likely to provoke measures to inhibit further loss of open land. People may have been pushed into more thinly settled areas by urban housing costs as much as pulled to these areas by the appeal of the countryside. In all three situations, the actions of land trusts and other non-profit organizations that purchase land and development rights may further limit housing supply.

The issue of rural housing supply cannot be addressed directly, as clear indicators of supply are not available for rural counties. However, the value of housing, which represents the joint outcome of supply and demand, permits some inference of county differences in supply. Absent supply differences, net migration and rises in housing values should be largely in accord. Extraordinary rises in housing values, beyond those expected on the basis of migration, suggest the presence of major constraints on housing supply. The following analysis uses this logic to explore the extent to which these constraints may be associated with particular landscape features.

For this analysis, the natural log of Census of Population and Housing's median value of 1-family homes on less than 10 acres and without any business on the property served to indicate the value of housing in both 1990 and 2000 (with change measured as the difference in the natural logs). The limit on the type of housing included reduces county variations in the value of housing stemming from differences in the housing mix (condos, mobile homes, etc.). Some differences in housing quality, such as size and year of construction, undoubtedly remain and could affect the results.

5.1. Results from housing value analysis

Table 3 presents the results of regressing change in the value of housing, 1990–2000, on net migration and the landscape and density measures included in Table 1. The 1990 median value of housing is included to reflect the expectation that housing values tended not to rise as much where they were already high in 1990. The results show that topographical variation, a mix of forest and open land, and water areas are associated with greater gains in housing values than expected on the basis of migration, suggesting a relative shortage of housing in highly scenic areas.

Cropland is also associated with relatively high gains in housing value. Low migration to areas with cropland could be a reaction to their costly housing rather than a reflection of landscape preferences. Despite gains in housing value associated with cropland, however, cropland was not associated with high housing values in 2000. The overall correlation was negative ($r = -0.22$) and the partial correlation between cropland and housing values, controlling for density and the other landscape measures, was essentially zero ($r = .008$). Migration to areas with cropland might have been higher had cropland remained associated with very low housing values, but housing costs and restrictions do not generally appear to account for the negative relationship found between cropland and migration. In retrospect, the relationship between landscape preferences and cropland may be more complex than the analysis has taken into account. Cropland may be valued by residents in urbanizing areas, where the alternative is housing tracts—hence the actions taken to preserve farmland. Cropland may be much less preferred where the alternative is open country.

Table 3
Coefficients (×100) from regression of 1990–2000 change in median housing[a] value ($\log_e$) on landscape, density, net migration, and initial housing value

Measures	B	S.E.	$Pr > \|t\|$
Forest (%)	0.371	.045	<.0001
Square of forest	−0.0030	.0005	<.0001
Water area (ln %)	0.962	.342	.0050
Topography scale	0.948	.075	<.0001
Cropland (%)	0.327	.019	<.0001
Population density (ln)	−7.52	1.83	<.0001
Square of density	.56	.16	<.0001
Net migration, 1990–2000	72.75	2.95	<.0001
Median housing value, 1990[a]	−14.95	1.10	<.0001
Constant	130.7	15.11	<.0001
R^2 (adjusted)	.351		
N	2209		
Maximum			
Forest[b]	35.1		
Minimum			
Density (ln)	6.66		
Persons per square mile	39.0		

[a] Includes only owner-occupied 1-family houses on up to 10 acres with no businesses on property.
[b] Maximum assumes that half of land not forested is cropland.

In the case of density, the signs of the coefficients are reversed from those of the migration equations, suggesting that housing availability may be limited at both low and high levels of population density. While high housing values may discourage migration to the densest rural counties, housing availability is not the major motivation for migration to counties with relatively low density, at least according to the evidence here.

5.2. Limitations on migration to highly scenic areas

According to the above analysis, constraints on the availability of housing may be reducing migration to highly preferred landscapes. The evidence is indirect, however, and the migration regression for 2000–2005 reported in Table 1 indicates that migration still favoured areas with varied topography, a mix of open land and forest, and surface water. Constraints on migration, if any, are likely to be strongest in the most highly scenic areas. In the following analysis, I identify the most scenic counties and look for evidence that, consistent with the evaluation of changes in the value of housing, migration to these counties has slowed.

To identify the most scenic counties, a landscape vector was created using the coefficients for the forest, water, and topography measures in the migration side of the equation in Table 2

Table 4
Housing values and net migration by landscape vector score

Landscape vector score (S.D. units from mean)	N	Average median value of housing units[a] (rural average = 100)		Average net migration (%)	
		1990	2000	1990–2000	2000–2005
Less scenic					
<−1	396	77	73	−2.1	−7.2
−1 to 0	736	89	89	4.0	−1.4
0–1	724	106	104	8.8	2.9
More scenic					
1–2	254	132	130	12.9	6.2
2 or more	99	152	186	21.2	4.7
All rural	2209	100	100	6.3	0.1

[a] Includes only owner-occupied 1-family houses on up to 10 acres with no businesses on property.

($LV = .11F - .0012Fsq + .33W + .23T$). Cropland was omitted, given the ambiguity discussed above, but the results that follow were substantially the same with cropland included in the vector. The 99 counties scoring 2 or more standard deviations above the mean on the landscape vector had an average median housing value that was about 50% above the overall rural average in 1990 (Table 4). By 2000, the average housing value in these highly scenic counties had risen to 86% above the rural mean. In 1990–2000, net migration was in these counties was considerably higher than migration across the other counties in the landscape spectrum (and a separate analysis showed that the most scenic counties had the fastest rates of population growth in both the 1970s and the 1980s). In 2000–2005, however, their average gain from net migration was below that of the next highest category on the landscape scale. It appears that constraints on housing are slowing migration to the most scenic counties, resulting in underestimates of the appeal of scenic environment for migration, at least in 2000–2005.

6. Discussion

This study has provided strong evidence that elements of preferred landscapes described by Ulrich (1986) – a mix of open land and forest, water, and topographic variation – have a strong bearing on recent migration in the rural areas of the U.S. Migration is an important behavioral indicator of substantial preferences—people “vote with their feet” (Tiebout, 1956), often at considerable economic cost and at the expense of social ties. Migration patterns are especially salient for landscape preferences research, given the common (if disputed) explanation for preferences as a substantially inherited quality, derivative of landscape features most suitable for the habitat of early man. From this perspective, the present research suggests that the predisposition for certain habitats has endured over time, perhaps regaining salience as fewer people make their livelihood from exploiting the land, transportation and communications systems have improved, incomes have risen, and people have become more willing to trade income for quality-of-life.

The migration analysis may even now underestimate the importance landscape, as we found evidence of housing constraints in the most highly scenic counties in 2000–2005. Rising cropland values and other constraints also appear to have raised housing values in areas with extensive cropland. The issue of rural housing supply and potential constraints on (and impetuses for) migration clearly merits more research attention than we have been able to give it here.

The study results suggest that landscape is an environmental feature deserving public attention. Landscapes are valued, but they are largely public goods, with benefits not completely reflected in the market place. Prompted in part by declining program support for agricultural production and the prospect of land abandonment, the assessment and monitoring of the scenic quality of landscapes is gaining increasing attention in Europe (Dramstad et al., 2006). In the U.S., the Forest Service has long paid attention to scenic value (Daniel, 2001). However, while scenic value has been recognized in U.S. environmental laws (Daniel, 1990), it is not recognized in many conservation programs. Thus, the U.S. Department of Agriculture’s Conservation Reserve Program, which has involved the removal of about 10% of all U.S. cropland from production, recognizes water and soil quality and wildlife enhancement in its priorities, but not recreational or scenic value. While conservation programs are generally thought to be inimical to rural community viability (since they take land out of production), the results here suggest that, depending on which lands are removed from production and the land cover that results, conservation programs could support rural community viability by enhancing rural scenic and recreational appeal not only for tourists but for residents as well.

More generally, the results suggest that support for environmental programs is likely to be greater to the extent that scenic benefits are incorporated. Ecological and scenic benefits may not always coincide (Gobster, 1999), but there would appear to be a great deal of overlap. For instance, people appear to be drawn most to areas with an even mix of forest and open land, a condition likely to be associated with habitat abundance and biodiversity.

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Appendix A

Table A1
Means, standard deviations and sources for measures

Independent variables	Mean	S.D.	Source
Landscape			
Forest (%)	37.2	31.8	U.S. Forest Service, Northern Research Station, St. Paul, MN
Square of forest	2390.9	2686.2	
Water area (standardized ln %)	−0.10	0.93	http://www.ers.usda.gov/Data/NaturalAmenities/
Topography scale	6.1	5.0	http://www.ers.usda.gov/Data/NaturalAmenities/
Cropland (%)	32.3	26.9	U.S. Census of Agriculture, 1992
Population density (ln)	5.1	1.2	U.S. Census of Population, 1990, SF1
Square of density	27.2	11.6	
Climate (standardized)			http://www.ers.usda.gov/Data/NaturalAmenities/
January sun days	0.030	1.002	
January temperature	−0.091	1.006	
July humidity (low)	0.1041	1.026	
Temperate summer	−0.048	0.991	
Employment by industry (%)			U.S. Census of Population, 1990, SF4
Farming	9.7	9.4	
Mining	2.2	4.4	
Manufacturing	18.5	11.3	
Business services	4.2	1.6	
Recreation	7.0	3.5	
Labor market			U.S. Census of Population, 1990, SF4
H.S. diploma, age 25–44 (%)	81.4	9.4	
B.A./B.S. degree, age 25–44 (%)	14.6	5.8	
Employment rate, age 16–64	67.6	7.7	
Median household income (ln)	3.1	0.2	
Demography			U.S. Census of Population, 1990, SF4
Population age 8–17 (%)	17.1	2.3	
Population age 62 and over (%)	19.0	4.6	
Native American (%)	1.8	7.0	
Black (%)	7.8	14.7	
Hispanic (%)	4.3	11.6	
Other			
Commute out of county (%)	25.2	15.0	U.S. Census of Population, 1990, SF3
Adjacent to metro area (0–1)	0.432	0.496	http://www.ers.usda.gov/Data/RuralUrbanContinuumCodes/
Public land (%)	9.7	16.7	U.S. Forest Service (see above)
College enrollment, age 18–24 (%)	21.5	13.8	U.S. Census of Population, 1990, SF4
Military employment, age 20–24 (%)	0.89	4.13	U.S. Census of Population, 1990, SF4
Growth 1990–2000			
Net migration	4.66	0.12	Johnson et al. (2005)
Employment	4.77	0.14	U.S. Bureau of Economic Analysis, Regional Economic Information System data files
Employment in adjacent counties	4.79	0.10	Calculated from above
N	2194		

Table A2
Reduced form equations from 3SLS analysis of net migration and employment change, 1990–2000[a]

Independent variables	Net migration, 1990–2000			Employment, 1990–2000		
	B	S.E.	*Pr* > |*t*|	*B*	S.E.	*Pr* > |*t*|
Landscape						
Forest (%)	0.1898	0.030	<.0001	0.1645	0.043	0.0001
Square of forest	−0.0021	0.000	<.0001	−0.0018	0.000	<.0001
Water area (ln %)	0.5618	0.210	0.0075	0.4870	0.318	0.1254
Topography scale	0.1930	0.056	0.0006	−0.0685	0.214	0.7472
Cropland (%)	−0.0663	0.013	<.0001	−0.0575	0.021	0.0053
Population density (ln)	5.5741	0.992	<.0001	6.4380	1.306	<.0001
Square of density	−0.6211	0.098	<.0001	−0.5384	0.125	<.0001
Climate (standardized)						
January sun days	0.8882	0.244	0.0003	0.7699	0.323	0.0176
January temperature	2.0548	0.280	<.0001	1.7813	0.576	0.0020
July humidity (low)	0.9505	0.321	0.0031	0.8239	0.593	0.1639
Temperate summer	0.5054	0.255	0.0477	0.4381	0.718	0.5452
Industry						
Farming	−0.1741	0.043	<.0001	−0.1073	0.054	0.0460
Mining	−0.6330	0.055	<.0001	−0.8171	0.082	<.0001
Manufacturing	−0.0863	0.038	0.0229	−0.1791	0.047	0.0002
Business services	0.1626	0.082	0.0472	0.3375	0.299	0.2583
Recreation	0.5219	0.073	<.0001	0.7966	0.119	<.0001
Labor market						
H.S. diploma, age 25–44 (%)	−0.1741	0.039	<.0001	−0.0430	0.038	0.2572
B.A./B.S. degree, age 25–44	−0.0287	0.044	0.5160	0.0950	0.071	0.1795
Employment rate, age 16–64	0.2033	0.046	<.0001	0.1465	0.105	0.1610
Med. household income (ln)	0.6097	3.049	0.8427	−6.4735	3.221	0.0450
Demography						
Population age 8–17 (%)	−0.6485	0.124	<.0001	0.6944	0.219	0.0015
Population age 62 and over (%)	0.1670	0.063	0.0077	−0.2472	0.089	0.0057
Native American (%)	−0.0342	0.031	0.2620	0.0713	0.054	0.1890
Black (%)	−0.1590	0.017	<.0001	−0.2625	0.029	<.0001
Hispanic (%)	−0.1625	0.021	<.0001	−0.1080	0.031	0.0004
Other						
Commute out of county (%)	0.1688	0.014	<.0001	0.1834	0.022	<.0001
County adjacent to metro area (0–1)	0.6183	0.382	0.1048	−0.4649	0.574	0.4180
Public land (%)	0.0111	0.018	0.5280	0.0739	0.022	0.0008
College enrollment, age 18–24 (%)	−0.0114	0.022	0.6105	0.0430	0.034	0.2001
Military employment, age 20–24 (%)	−0.2665	0.044	<.0001	−0.2937	0.066	<.0001
Adjacent county job growth 1990–2000	32.427	2.032	<.0001	28.110	3.055	<.0001
Intercept	303.177	11.101	<.0001	325.024	17.188	<.0001
R^2 (adjusted)	0.61			0.37		
N	2194					

[a] Coefficients and standard errors are multiplied by 100 for exposition.

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